"Experimental and Theoretical Study of Ionospheric Electron Content and Upper Ionosphere Ionic Processes by Means of Satellite Radio Transmissions"

Semi-annual Report

for the period

November 1, 1964 to April 30, 1965

Ionosphere Research Laboratory

The Pennsylvania State University

University Park, Pennsylvania

NsG-114-61

Table of Contents

1. Introduction

A number of experimental programs have been conducted during the report period, based on the use of radio beacon transmissions from satellites for the study of the ionosphere. These experiments involve the measurement and interpretation of the refraction, dispersion, and diffraction characteristics of the ionosphere on the beacon transmissions, as they are observed at ground level.

The program is at present in a very active experimental phase using the satellites S66 (Explorer 22) and BE-C, whose orbits are such that they cross this location respectively in the north-south and west-east directions. Some earlier investigations, using data from other satellites, have also been completed.

2. Research in Progress

2.1 Satellite Recording Program

The S66 satellite has been recorded regularly throughout the report period, with phase and amplitude data being taken on the frequencies 20 Mc/s, 40 Mc/s, 41 Mc/s and 360 Mc/s. Approximately 500 passes have been recorded on magnetic tape for analysis.

The recording system has been arranged to record automatically according to a preset schedule, and data collection is now routine. The data is generally of good quality, although some continuing difficulty has been experienced with the relatively low level of the 360 Mc/s signals in the low-gain antennas used. Approximately three passes of the S66 satellite are recorded each day. The BE-C satellite is recorded on a much more limited

schedule, with emphasis being placed on the recording of the five or six close consecutive passes on a few selected days, extending over a period of some 8-10 hours.

2.2 Electron Content Analysis

The initial analysis of recorded data is being made using the Faraday rotation dispersion technique to determine the vertical column electron content. The scaling of differential rotation angle data from the interleaved nulls seen on a single linear dipole receiving antenna at the frequencies of 40 Mc/s and 41 Mc/s is subject to considerable error if the rotation rate between nulls is not constant. To avoid this error, the differential rotation angle is measured once only each pass, at a time around which the rotation rate is constant, and preferably somewhat to the north of the station where the number of rotations is small. This number is then converted to an equivalent number of rotations at this time for one of the signal frequencies using the known dispersion relation. At succeeding nulls for this frequency, integral increments are added to this figure. These data are then reduced by computer to electron content at each null positon by combining orbital data and magnetic field data. First order analyses are upgraded in the same program by the use of the equations for the second-order effects in the propagation path.

From this analysis, the variation of electron content with day, time of day and latitude is derived, and these data are forming

the basis for an initial report. Future plans are to include doppler effect data in the analysis, particularly for the study of irregularities in ionization content.

2.3 Sunrise Studies

A study of sunrise effects at low magnetic latitudes has now been completed, using earlier recorded data from the Transit 4A satellite. A total of sev en satellite passes occurring sufficiently close to sunrise were analyzed, and the observed rate of increase of electron content was related to the incident photon flux. By using sunrise data, the effects of recombination reactions were minimized, but even within 30 minutes of sunrise the correction for these effects was found to be substantial.

The conclusions of the study were that, with reasonable assumptions for the rate coefficients of the recombination reaction, and with the assumption that primary molecular ions in the F region (particularly N_2^+) are lost by dissociative recombination rather than by charge exchange reactions, the calculated values of photon flux are in good agreement with those measured by Hinteregger et al.

2.4 Scintillation Studies

Spaced receiver amplitude and phase data are recorded regularly over a 3000' NS baseline interferometer, operating at the harmonic frequencies of S66 of 20 Mc/s and 40 Mc/s. Correlation studies of these data will lead to measures of the height and the

height distribution of diffracting ionospheric irregularities. Particular interest is directed to the consistency of the results from the phase and amplitude data, since the former has theoretically less height dependence than the latter.

The BE-C satellite passes approximately normal to this baseline, and with this geometry it is hoped to achieve some resolution of the morphology of irregularities transverse to the magnetic field direction.

It is planned to install a central receiving site along the interferometer baseline, to facilitate data presentation and analysis.

2.5 Equatorial Observations

A satellite receiving station was installed at Huancayo, Peru during March 1965, and this has been providing routine measurements of phase and polarization rotation data since that time. Particular interest is being placed on the quasi-transverse propagation region, which is quite extensive at the 20 Mc/s frequency, and on the magnitude of the second order propagation effects which maximise at low latitudes.

A study of the transequatorial distribution of ionization has been completed, using polarization data taken at Huancayo from the Transit 4A satellite. This was concerned particularly with the form, depth and diurnal development of the equatorial trough, and diffusion and drift theories of its origin.

3. Papers and Publications

"Satellite Studies of the Distribution of Ionization Across the Magnetic Equator" by J. D. Kolesar, I.R.L. Scientific Report No. 235, February, 1965.

"Second-Order Effects in High-Frequency Transionospheric Propagation" by W. J. Ross. Journal of Geophysical Research, 70, No. 3, p. 597, February, 1965.

"Analysis of Second-Order Corrections Applied to Radio Beacon Satellites" by N. D. Foltz. Presented at the URSI-IEEE Fall 1964 Meeting, Urbana, Illinois.

"Determination of the Solar Ionizing Flux from Sunrise Satellite Measurements" by A. A. Gran. Presented at the URSI-IEEE Fall 1964 Meeting, Urbana, Illinois.

4. Personnel

William J. Ross (Ph.D. Auckland University, 1955) Professor of Electrical Engineering.

J. Wayne Porter (M.S. University of Pennsylvania, 1959) Doctoral Candidate in Electrical Engineering.

Alfred A. Gran (B.A. Hartwick College 1963) Graduate Assistant in Physics.

Steven L. Solomon (B.S. Drexel Institute of Technology 1962) Graduate Assistant in Physics.

Robert J. Sweet (B.S. Pennsylvania State University 1965) Graduate Assistant in Electrical Engineering.